Direct photon production in $p+p$ at $\sqrt{s}=200$ GeV, and its double spin asymmetry measurement

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At RHIC-PHENIX spin program, direct photon production is believed to be a golden channel to access the gluon polarization in proton.

With Run3(2003) data set ($\mathcal{L}=0.24\mathrm{pb}^{-1}$), we improved the precision of measurement of its cross section[1]. The analysis starts from the inclusive photon in the PHENIX detector[2], and backgrounds, mainly π^0 decay photons, are subtracted statistically. Fig. 1 shows the spectra with a Next to Leading Order (NLO) calculation. The result is described well by the theory calculation.

The double spin asymmetry, defined by the difference of production ratios between parallel and anti-parallel helicities of the colliding bunches of protons divided by the sum, is sensitive to the gluon spin polarization. The statistical background subtraction for each helicity state doesn't provide the highest precision. Instead we subtract the background asymmetry afterward[3]. The asymmetry of the signal (A^{sig}) is calculated from the asymmetry of all photon (A^{raw}) and the one of background (A^{BG}) by $A^{sig}=\frac{A^{raw}-rA^{BG}}{1-r}, \sigma_{A^{sig}}=\frac{\sqrt{\sigma^2_{A^{raw}}+r^2\sigma^2_{A^{BG}}}}{1-r}$, where r is related to the purity defined by the ratio of BG to raw, and $\sigma_{A^{sig}}$ is the statistical uncertainty.

To get purer sample (=lower r), we applied an isolation cut on the photon sample since direct photons are expected not to come with other jet activities. We also measured that $80\sim 90\%$ of direct photons satisfy the isolation cut for the region of p_T more than 7 GeV/c[1].

It should be fair to measure the asymmetry of background (A^{BG}) using photons associated with π^0's decay partner. Based on real Run5(2005) data ($\mathcal{L}=2.5\mathrm{pb}^{-1}$), assuming the statistical uncertainty to be the root mean square of the yield, Fig. 2 shows the size of $\sigma_{A^{sig}}$. The bin size is larger above $p_T=10\mathrm{GeV}/c$. It can be seen an advantage of the isolation cut in the figure. In the case without the isolation cut, the $\sigma_{A^{sig}}$ is underestimated, because the combinatorial background contamination in the π^0 tagging process is not taken into account.

In summary, we proved that the theoretical baseline is applicable in direct photon production at $\sqrt{s}=200$ GeV $p+p$ collisions by the cross section measurement. For the spin asymmetry measurement, the precision was

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evaluated. The isolation cut improves the measurement. The values in Fig. 2 are scaled by luminosity $(1/\sqrt{\mathcal{L}})$ and beam polarization $(1/P^2)$.

The machine performance is improving each year in both luminosity and polarization. We have collected $\mathcal{L} = 7.5\mathrm{pb}^{-1}$ with longitudinal polarization at $P = 62\%$ in Run6(2006). In the following 3 years, we plan to accumulate $\mathcal{L} = 65\mathrm{pb}^{-1}$ in total. By then, the experimental uncertainty of this channel will be comparable to our current knowledge of gluon polarization.

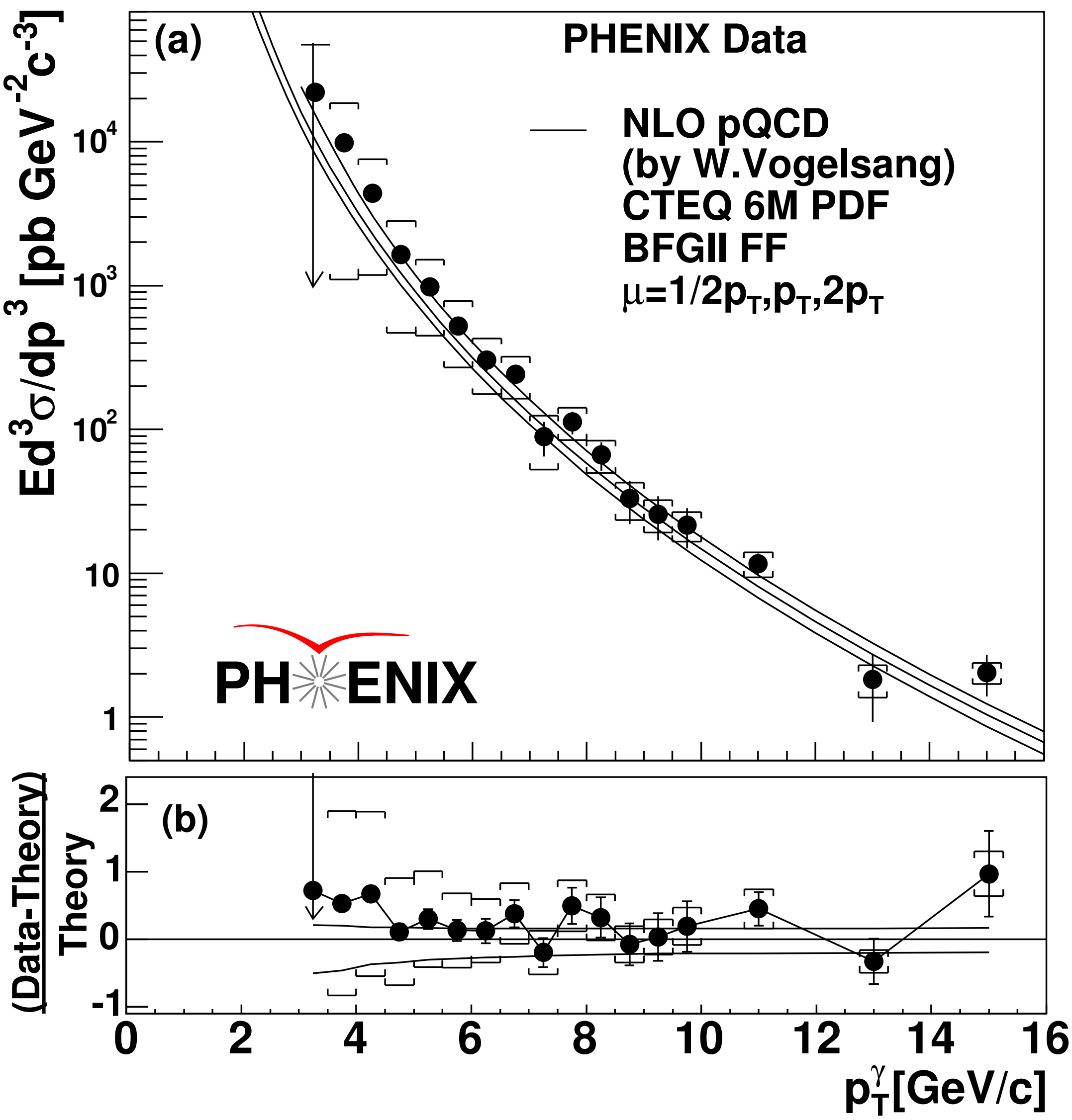

Fig. 1. Direct photon spectra with NLO pQCD calculation

References

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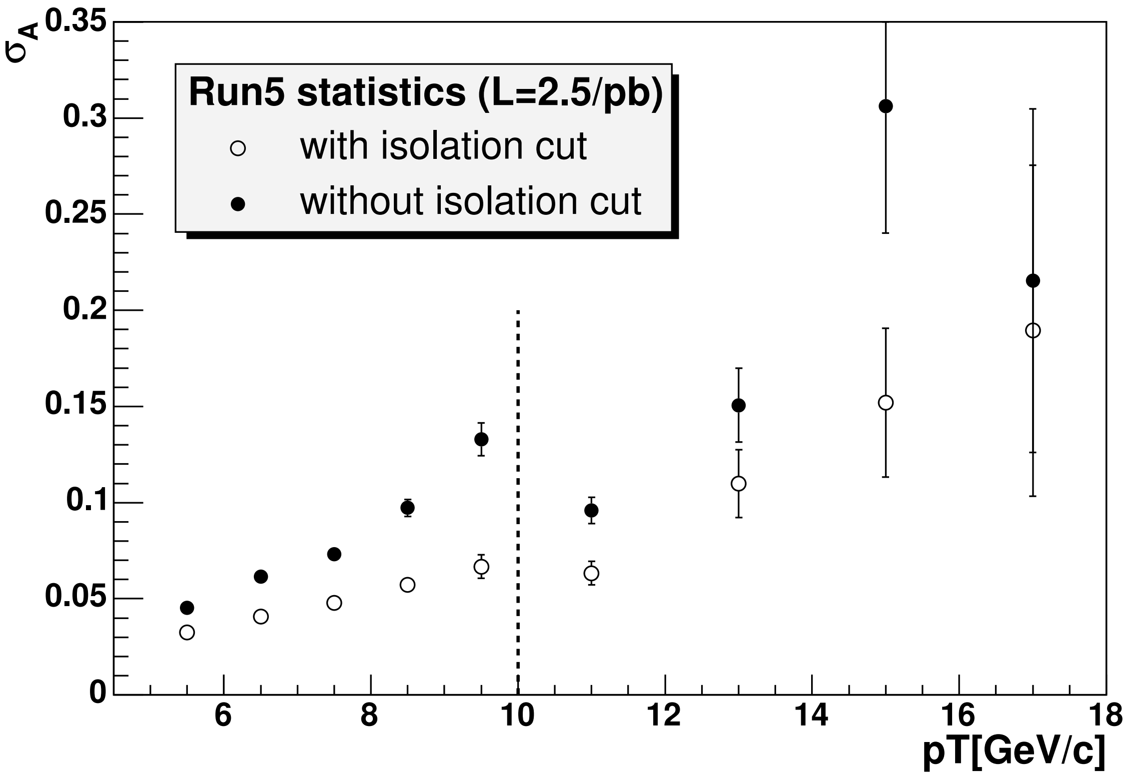

Fig. 2. σ_A estimation using Run5pp statistics.